



Materials Science Work at NASA Ames Research Center



Presentation to:

Aranui High School,
Christchurch,
New Zealand

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ELORET



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Outline

Research Center

- NASA Ames Research Center
 - TPS Development, including testing
 - Materials for the Shuttle
 - Ablators
 - Coatings
 - Integrated Vehicle Health Management
 - Sharp leading edges
 - More fun at work
 - Using the latest technologies
 - Playing with blowtorches
 - What you should learn in high school and university to help you later
 - Summary



NASA Entry Vehicles and Missions Supported by Ames

Sharp Body Concepts

SHARP-B1&B2



X-33

X-34

SPACE SHUTTLE



RLV SHUTTLE UPGRADES



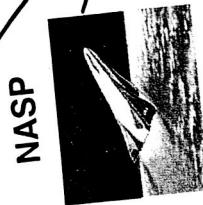
Shuttle Upgrades



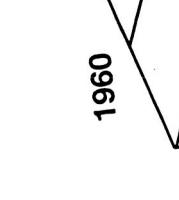
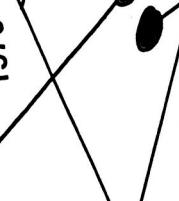
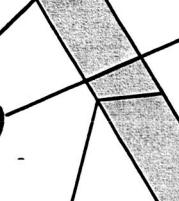
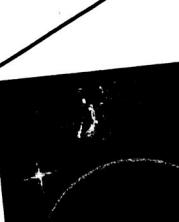
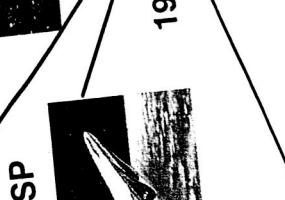
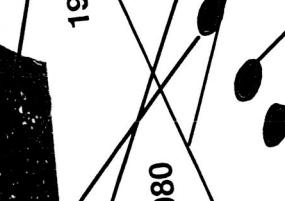
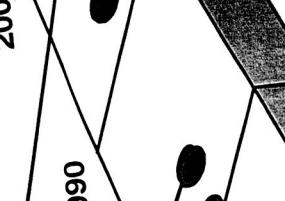
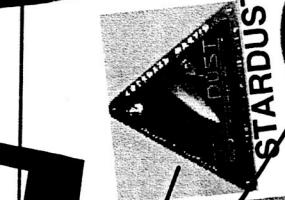
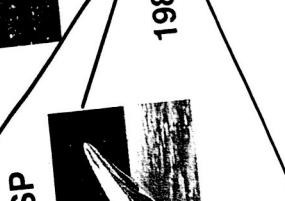
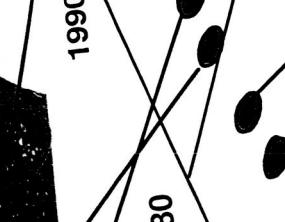
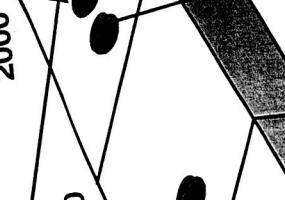
PLANETARY
• Mars 2005/07
• Mars Sample Return
• HEDS

NASP

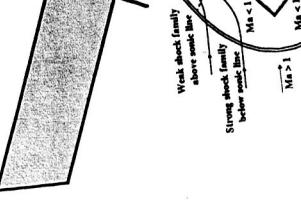
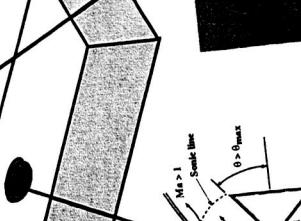
APOLLO



1960 1970 1980 1990 2000



MARS DS-2



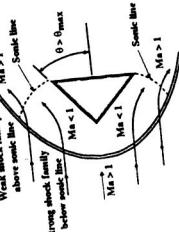
GALILEO

PIONEER-VENUS

VIKING

PAET

BLUNT BODY CONCEPT
(H. Allen)





TPS Development

- TPS Material Development requires :
 - Material properties:
 - Generally low density
 - Refractory
 - Impact Resistance
 - Low Catalycity
 - High Emissivity
 - Modeling of behavior
 - Defining operating environment
 - Quantifying response to thermal and structural loads





TPS Development (cont'd)

– Testing

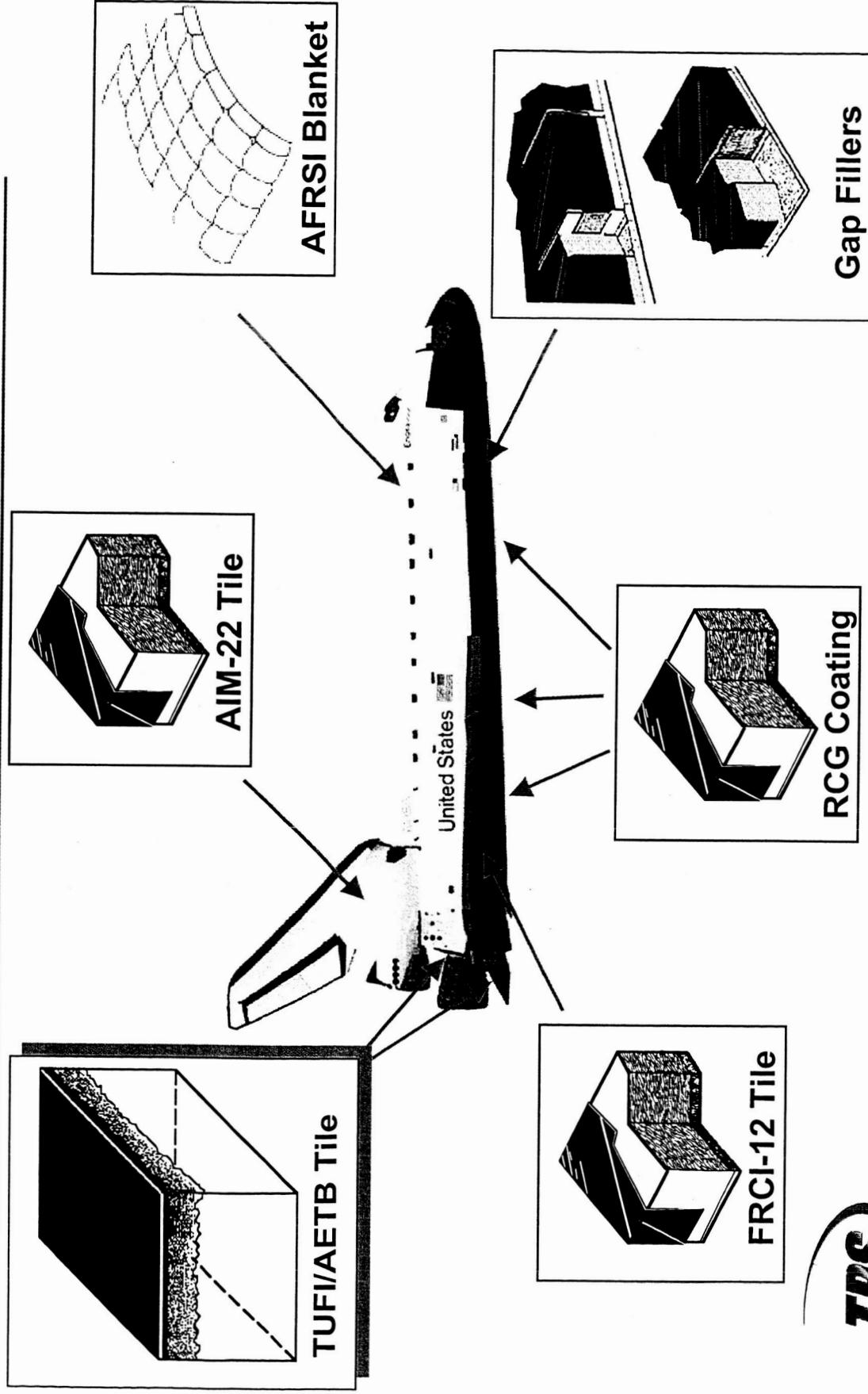
- Laboratory-based
- Creating conditions as close to flight as possible
 - Atmosphere (gas enthalpy)
 - Pressure
 - Heat Flux
- Arc Jet can create an environment as close as possible to flight
 - Flight Testing
- NASA-Ames is capable of handling every stage of TPS development from conception, material properties investigations, and modeling, to fabrication, testing and end product delivery





Ames-Developed Thermal Protection Materials Adopted to Date on Shuttle

Ames Research Center



TPS

Thermal Protection Materials and Systems Branch

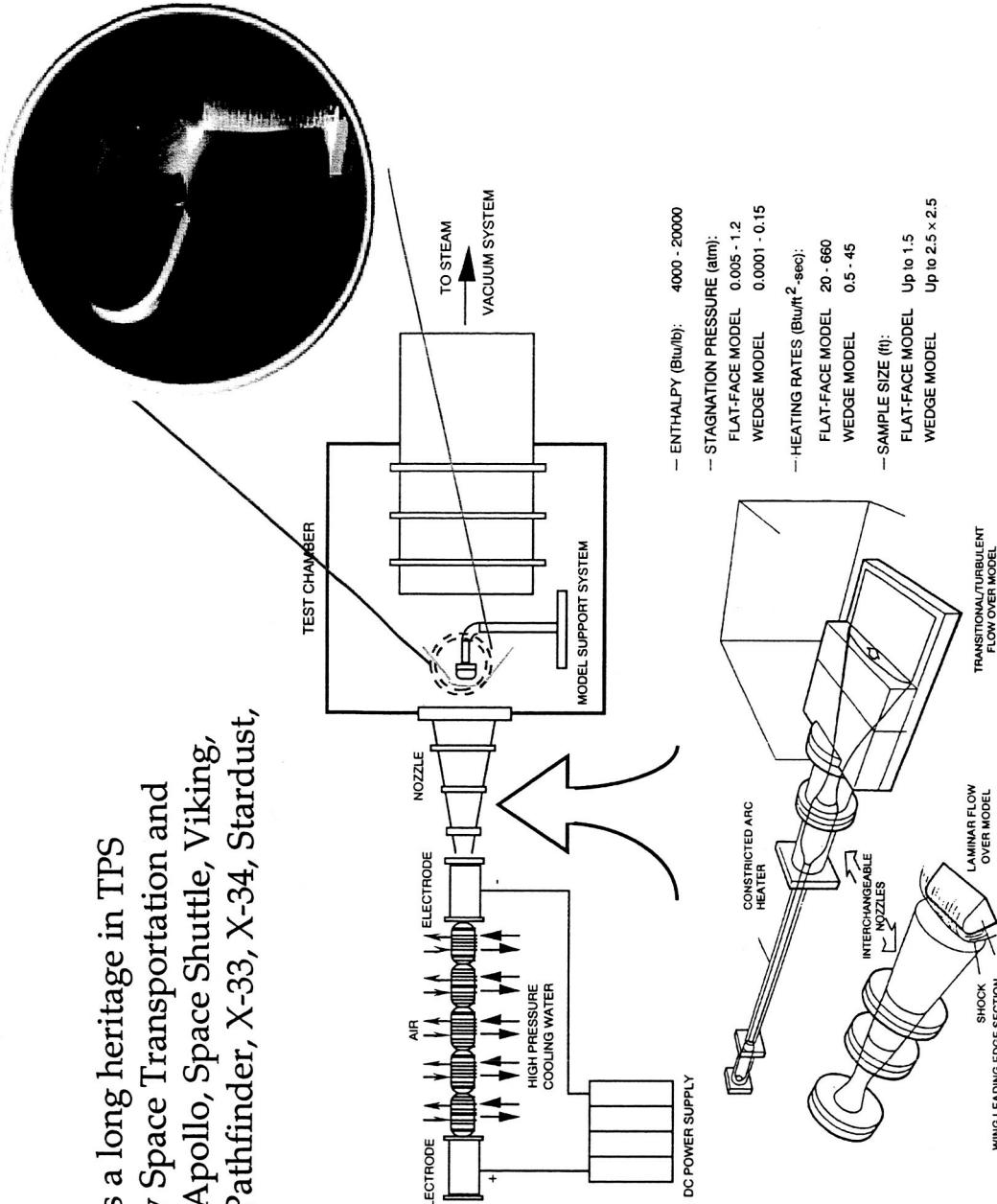


Typical Arc Jet Test Leg

- The Ames Arc Jet Complex has a long heritage in TPS development for every Agency Space Transportation and Planetary program, including Apollo, Space Shuttle, Viking, Pioneer-Venus, Galileo, Mars Pathfinder, X-33, X-34, Stardust, SHARP-B1, and SHARP-B2.

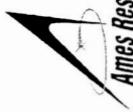
- Presently on the critical path for X-37, Shuttle Upgrades, SHARP-L1, Generation 2 & 3 RLVs, Mars Landers '03 and '05 and Mars Sample Return Earth Return Vehicle

- The Arc Jet Complex is currently operating at extremely high production rates, averaging ~400 tests per year.



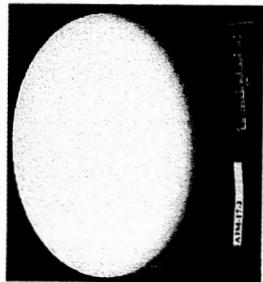


Ames' Light Weight Ceramic Ablator Family Ease of Manufacturing and Performance



Ames Research Center

- SIRCA
 - Silicone Impregnated Refractory Ceramic Ablator
 - For medium heat fluxes
 - Made by infiltrating silicone resin into a silica-based tile
- PIKA
 - Phenolic Impregnated Carbon Ablator
 - For high heat fluxes Phenolic resin infiltrated into carbon fiber preform



SIRCA



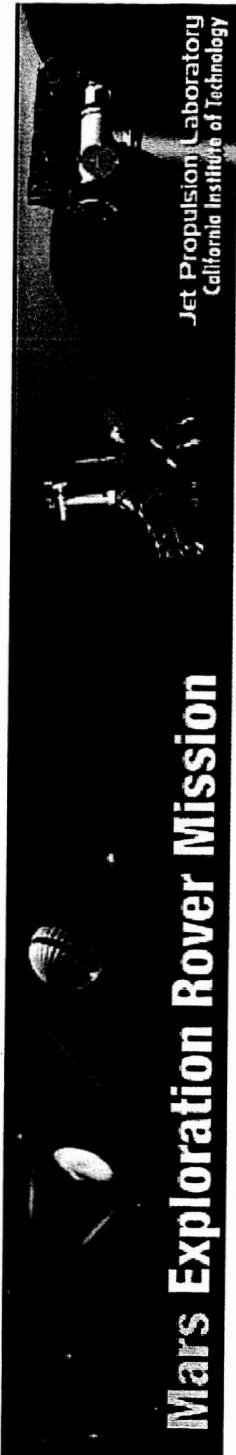
PIKA

APPLICATIONS

- SIRCA: Mars/Pathfinder, X-34, Mars Exploration Rover, Mars Exploration Rover (A & B)
- PIKA: Stardust



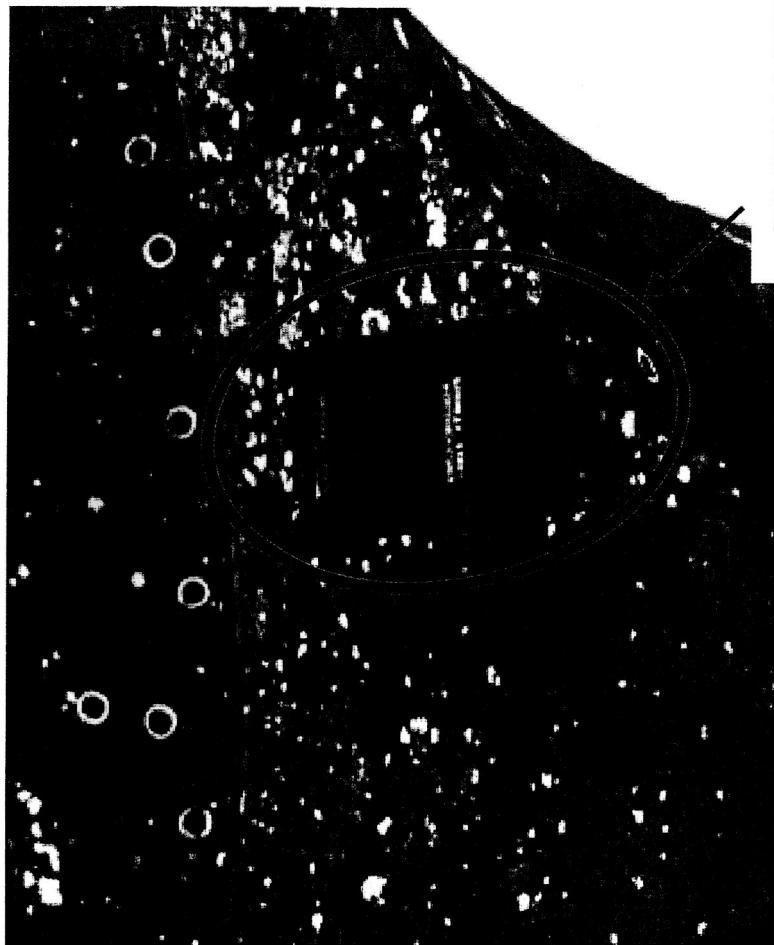
Mars Exploration Rover Mission



Jet Propulsion Laboratory
California Institute of Technology



Shuttle Flight Testing of LI-900/RCG vs AETB-8/TUFI in Base Heatshield



**TUFI/AETB-8 Tiles
Undamaged After
Three Flights**

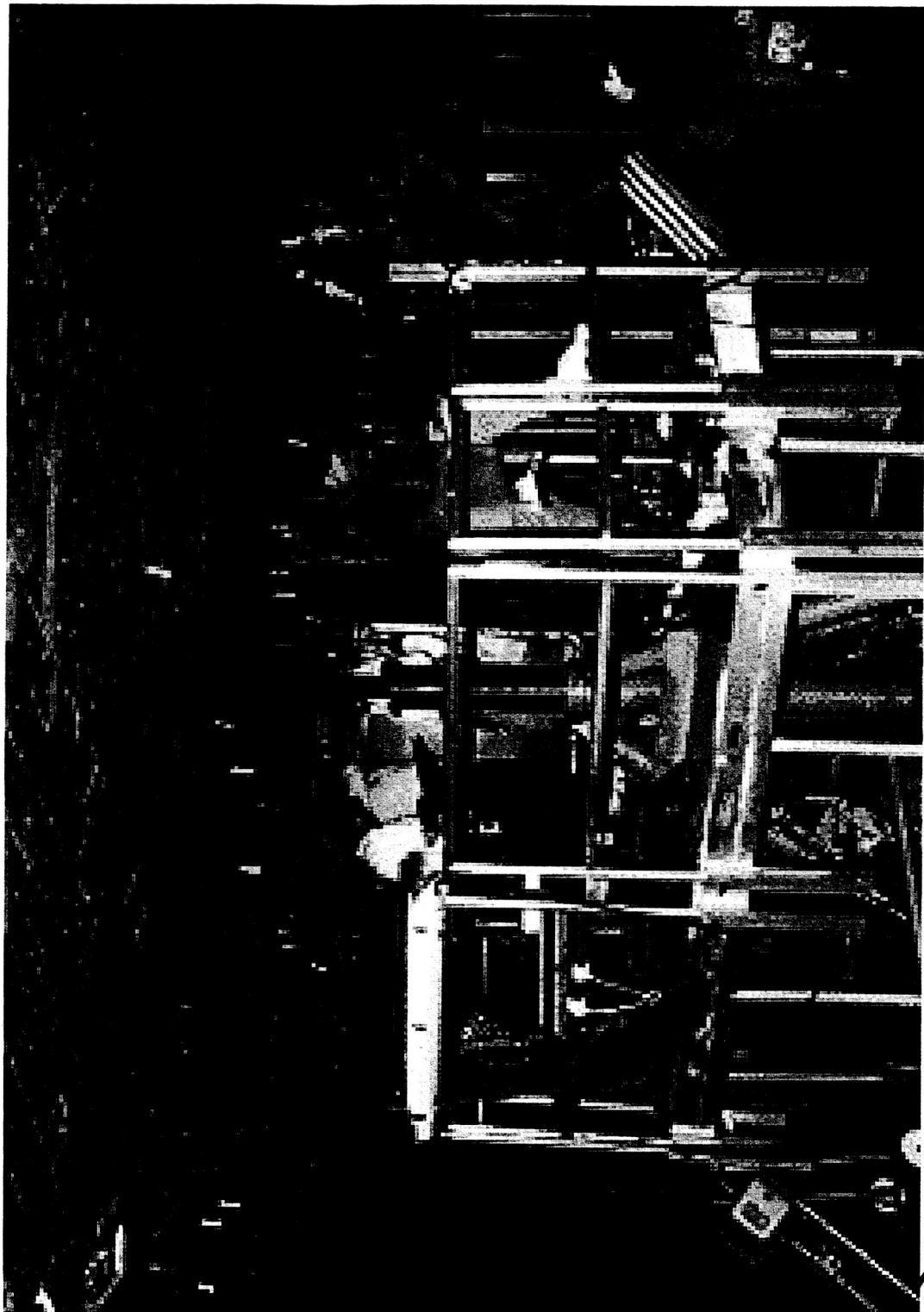


Thermal Protection Materials and Systems Branch



Health Monitoring:

Shuttle TPS Inspection & Maintenance

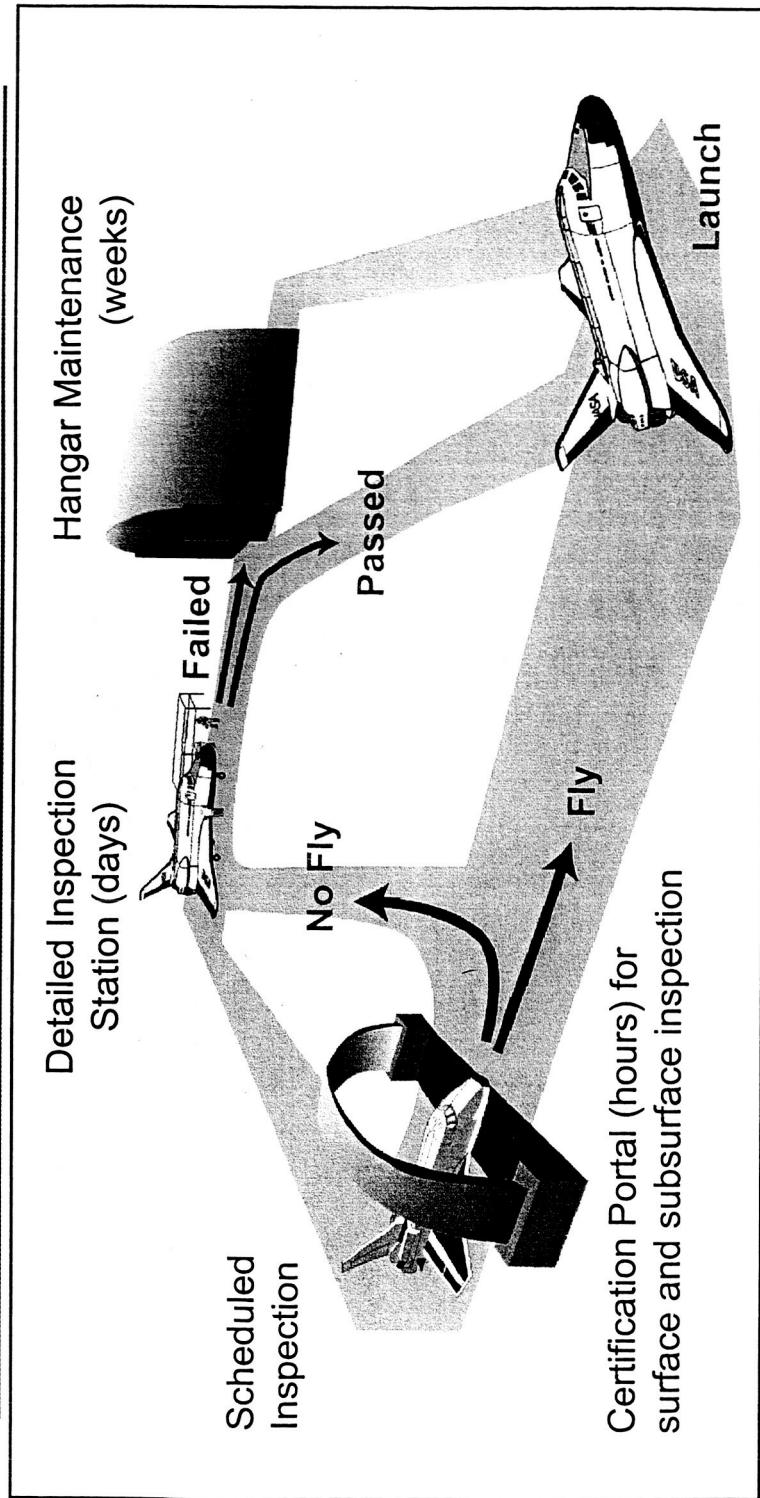
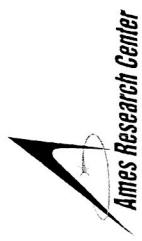


TPS

Thermal Protection Materials and Systems Branch



Futuristic TPS Inspection Process



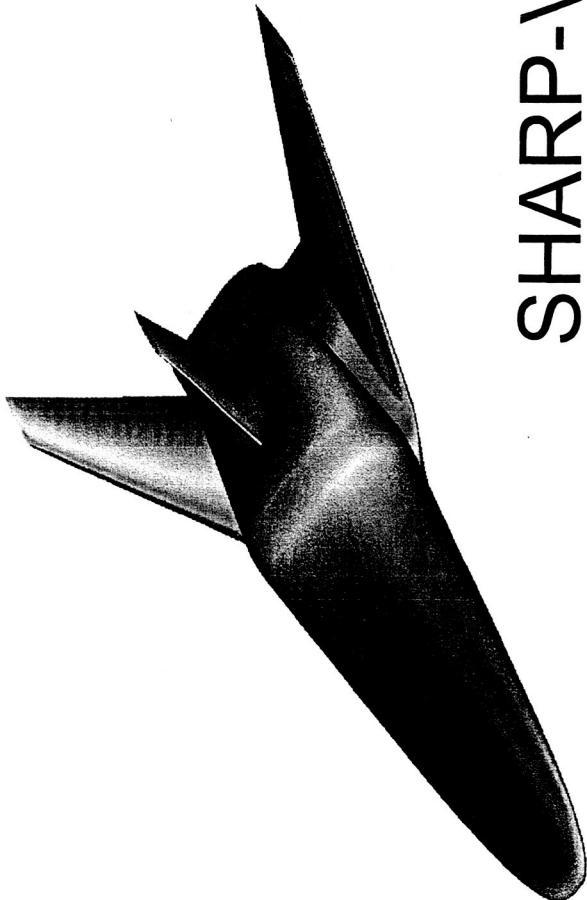
- The portal inspects the TPS as the vehicle passes.
 - Scan the exterior surface for damage.
 - Query the status of subsurface health sensors.
- Alternatively: automated scanning heads or small robots can perform the inspection.

TPS



Sharp Leading Edges Provide Increased Safety and Performance

- Reduce propulsion requirements by decreasing drag
- Increase maneuverability
- Increase time during ascent for safe abort to ground
- Increase out-of-orbit cross range which enhances safety by increasing the number of potential landing sites



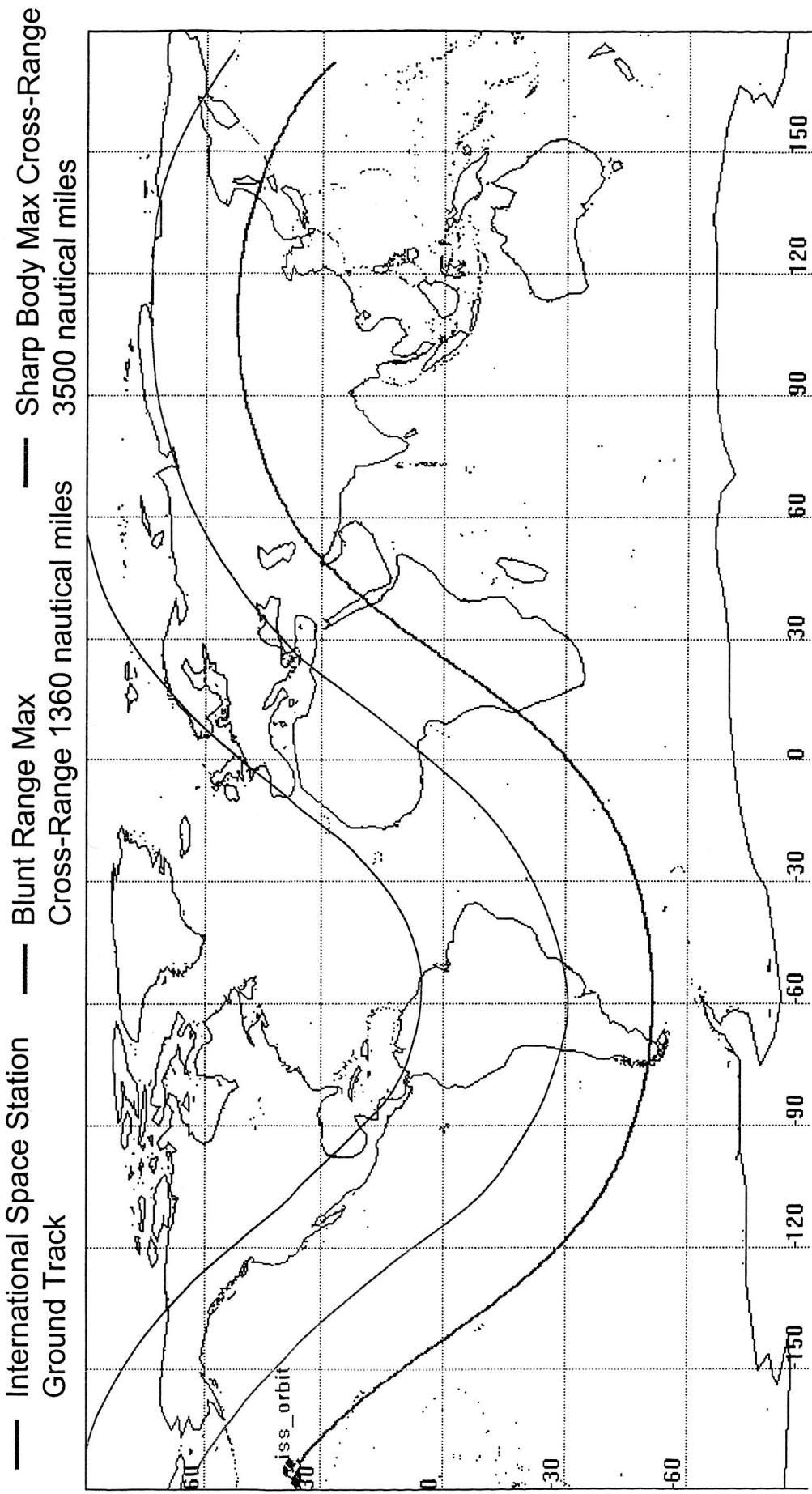
TPS

SHARP-V5

Thermal Protection Materials and Systems Branch

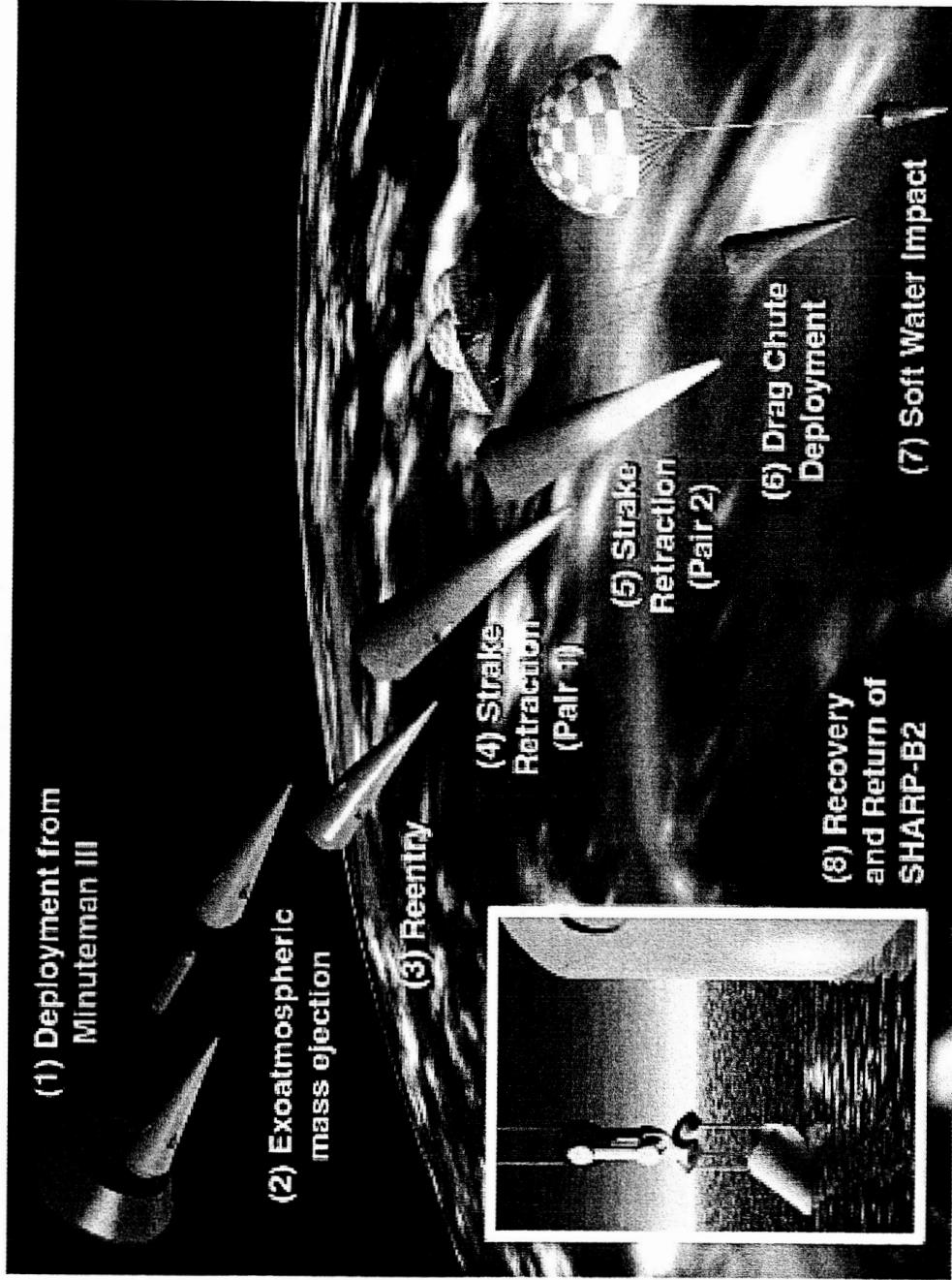


ISS Ground Track vs. Cross Range





Missions Like SHARP-B2 Provide a Method to Evaluate Materials in a True Hypersonic Reentry Environments

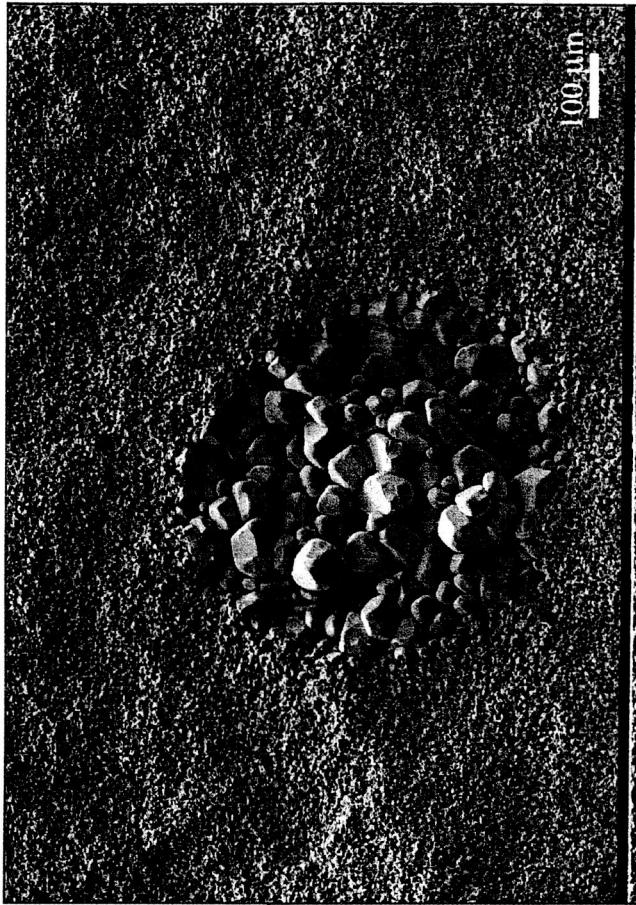
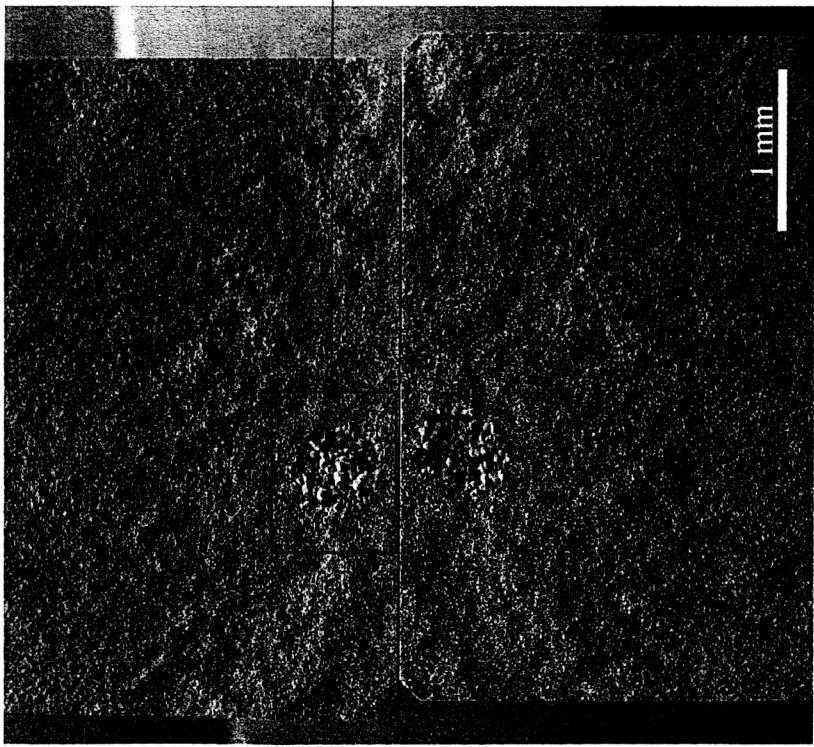


IPS



Large Processing Defects Are Observed

HfB_2/SiC Flexural Bar: $\sigma = 75 \text{ MPa}$, $T = 1200^\circ\text{C}$



- Large grain HfB_2 agglomerates present in microstructure due to incomplete mixing.



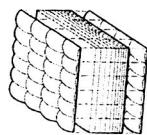
Where we are going:

Mission Pull & Timeline for TPS contributions to NASA programs

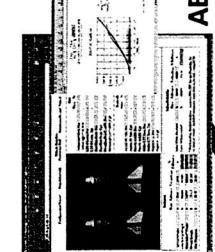
2002 - 2007

- TPS Focused System Analysis
- In-House Dev of UHTC
- Advanced Tiles & Flex.
- TPS - IVHM - Autonomous Diagnosis and Repair
- Rapid, Reliable Design Tools (AEE)
- Transition ->Turbulence

UHTC's



Rigid and Flexible TPS



AEE



Mars Smart
Lander



Planetary Exploration &
Technology Development Programs

SIRCA
Light Weight Ablators Development

2008- 2013

High L/D
Crew Transfer Vehicle



3rd Gen TSTO



Sample Return



HEDS Aerocapture
& Lander Vehicles



OP Aerocapture
Mid/high L/D vehicle

OP Deep Atmospheric Probes



Mars Smart
Lander



PICA
Thermal Protection Materials and Systems Branch

2014 - 2025

- TPS Focused System Analysis
- Afterbody CFD
- Coupled Radiative/Convective
- Ablator Development
- Gas/Surface Interactions
- Rehab Giant Planet Arc Jet
- Instrumentation R & D
- Transition ->Turbulence

Thermal Protection Materials and Systems Branch



Summary of NASA Ames Materials Science work

- Selection of thermal protection materials is based on environment and use (heat flux, temperature, reuse requirements, density)
- Materials with very high temperature capabilities will allow for sharp leading edges and improved vehicle performance and safety
- NASA Ames has a long heritage in the development of Thermal Protection Systems, and continues to fulfill NASA's missions through ongoing research and development
 - This is an exciting field in which to work





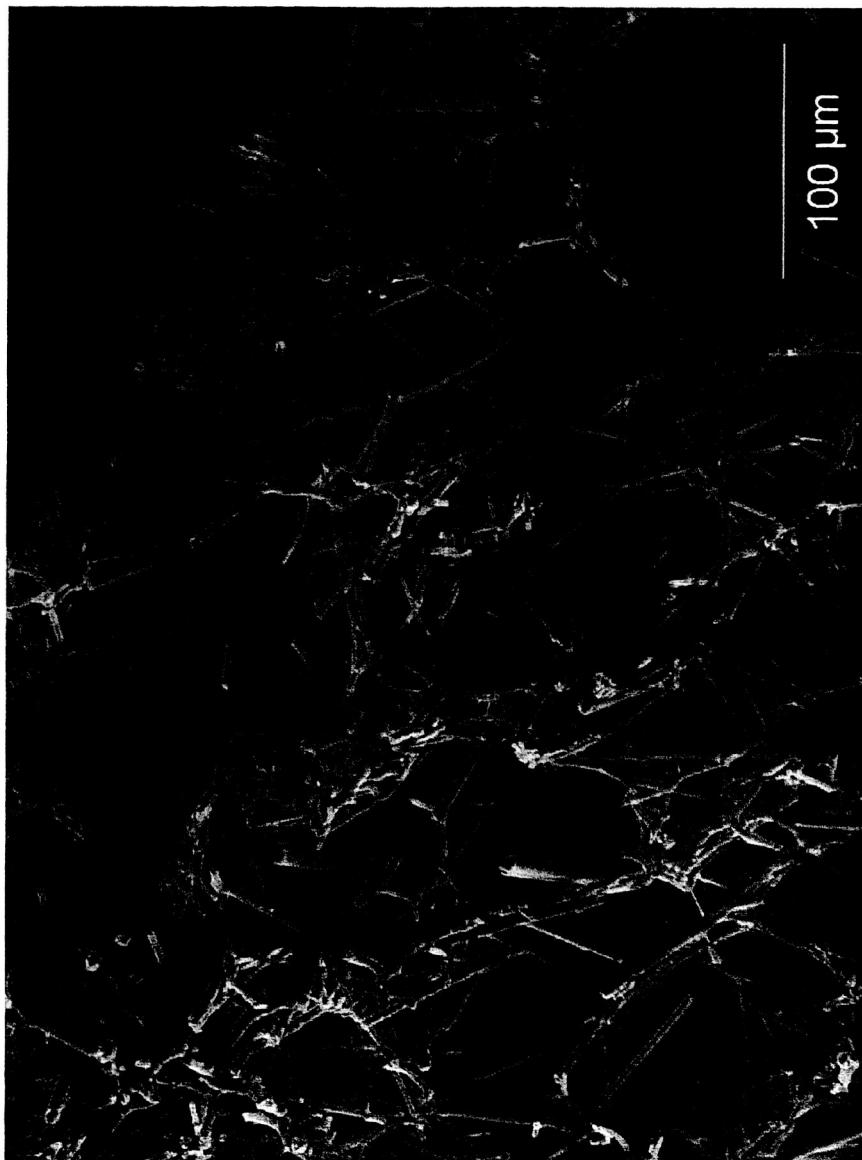
Outline

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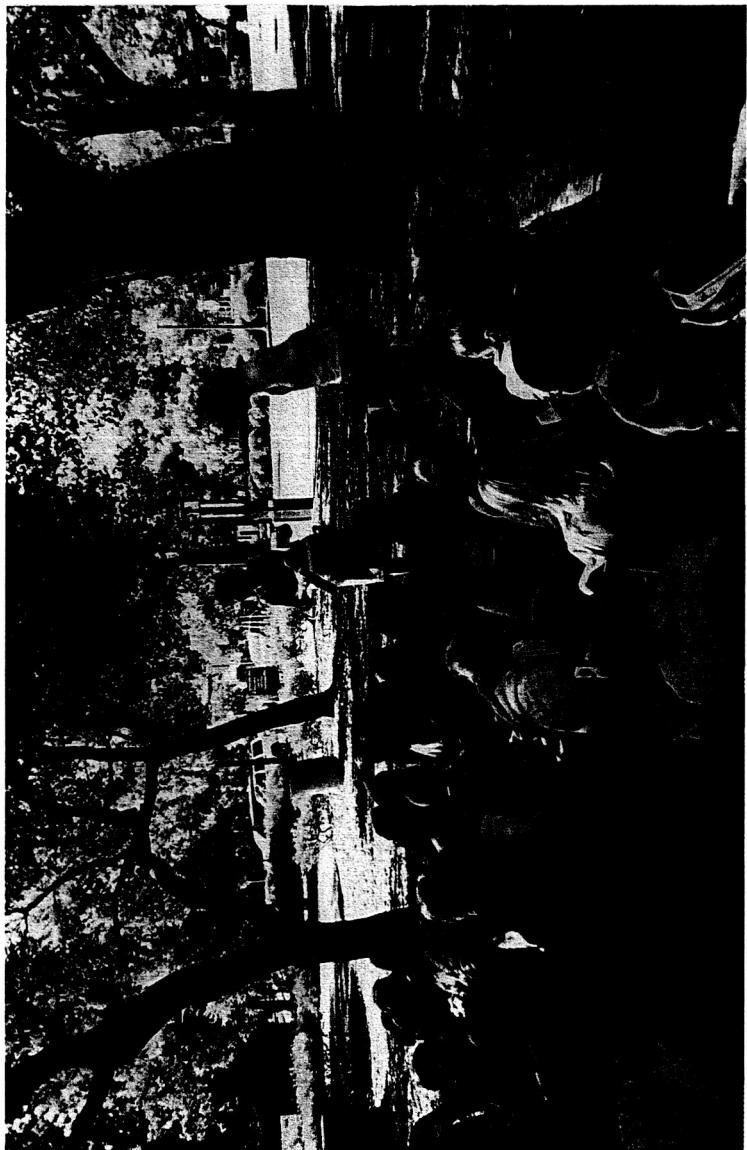
Microstructure of Shuttle Tile (LI-900), Uncoated



Thermal Protection Materials and Systems Branch



Sally Ride Science Camp



July, 2003, Intermediate School girls
Stanford University, Stanford, California

TPS

Thermal Protection Materials and Systems Branch

Fun with a Blowtorch



Thermal Protection Materials and Systems Branch



Informal non-scientific anonymous survey

- Taken in April, 2003 at the Thermal Protection Materials and Systems Branch of NASA Ames
- Interviewed seven recent graduates (graduated within the last two years):
 - 4 women, 3 men
 - 6 Universities
 - 1 with 2 Bachelor's Degrees
 - 2 with Master's Degrees (one has also worked as an instructor at a state college)
 - 4 with PhD's
 - All now working in Research Scientist capacity, some as Project Managers, Lab Managers
- Asked them the following questions:
 - What are you glad you learned in college?
 - What do you wish you had learned/done/is there anything you regret not doing?
 - What advice would you give to college students?
- The following information represents their responses.
 - Supported by my many years of experience.





People Skills

- DO

- Learn how to work in groups
 - In real life, you are not alone; personality compatibility/clashes directly affect the performance of everyone in the team, AND the project results
 - In the work environment you need to know how to explain things in simple terms and to put yourself in someone else's shoes
- Take advice from a Project Manager
 - Interacting with people is the MOST important
 - The technical aspect is pretty small - what makes a project go well is coordinating, motivating, having people work together
 - If at all possible take a class or two in team-building or “dealing with difficult people”





Involvement in school



- Do:
 - Use the school resources
 - Take advantage of career days
 - As much as you can to take the initiative to work with teachers and professors
 - Most people do not
 - Ask questions if in doubt - a lot of times people do not do this, as they do not wish to embarrass themselves, but do not be shy - when you ask, the rest of the group will start asking. Not clarifying at the outset makes confusion set in!
 - Take extensive notes on experiments; you may have to remake the samples one day, and so you need to know how





Involvement in school (cont'd)



- Do:
 - Be willing to learn new things; try, regardless of what others are doing
 - Employers look for people with the “spark in the eye”, who are “fired up” about what they do, and are willing to take a different approach
 - Learn presentation skills on:
 - Yourself, your project
 - A presentation can determine whether you secure a job, or if something is funded





Do not!

- Throw out your notes
- Throw out/sell your textbooks
- Assume you will not work in a specific place - you may become interested in that exact thing





School is unique



- Do
 - Have fun in school, study hard, but do the best you can to take advantage of the right opportunities to enjoy outings. You will miss it. Life is fun, but not in the same way.
 - Try and become involved in school life. The experience is unrivaled and can be quite enriching.
 - Take advantage of university-abroad programs



Summary

- You may never know where you may end up!



TPS